“I hereby declare that I have read this report and in my opinion this report is sufficient in term of the scope and quality for the award of Bachelor of Electrical Engineering (Power Electronic and Drive) With Honours”

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Supervisor : Mr. Loi Wei Sen
Date : ............................................................
COMBINE INFRARED LOCK-IN THERMOGRAPHY AND CURVE TRACER INTO AN INTEGRATED SYSTEM

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A report submitted in partial fulfillment of the requirements for the degree of Electrical Engineering (Power Electronic and Drive)

Faculty of Electrical Engineering
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JUNE 2013
“I hereby declare that this report is result of my own effort except for works that have been cited clearly in the references.”

Signature : .................................................

Author : Phung Lee Mun

Date : ......................................................
DEDICATION

To my beloved God, family, supervisor (Mr. Loi Wei Sen), co-supervisor (Mr. Ng Kiong Kay), and my friends for giving assistant to complete this final year project successfully.
ACKNOWLEDGEMENT

Taking this opportunity, I would like to express my gratitude to Universiti Teknikal Malaysia Melaka (UTeM) for offer this final year project (PSM) to all its last year students. I would also like to thank Infineon Technologies (Malaysia) Sdn Bhd for giving me this great opportunity to proceeds company project as my PSM with the greatest exposure towards semiconductor industry. I am utmost grateful and delight to receive this project offer from such a prestigious and worldwide company.

First and foremost, I would like to thank my respective supervisor, Mr Loi Wei Sen for giving me an opportunity to carry out my PSM under his supervision. I would also like to thank my respective co-supervisor, Mr. Ng Kiong Kay for his guidance and support for the project during my attachment in the company. His advices shall be a guide to me in my future undertakings. I am deeply thankful for his kindness and willingness in teaching me to handle variety of machines and explained theories and operations of processes involved in the semiconductor industry.

Last but not least, a big thank you to my dearest family for having being there for me. Without them, my PSM will not turn out to be so great. And I strongly believe that all the precious experience that I gained during the 2 semester of PSM will make me become a more competent engineer in the near future.
ABSTRACT

Both machines curve tracer and Infrared Lock-in Thermography (IR-LIT) are for troubleshooting failure semiconductor devices. IR-LIT is basically based on the application of a periodic input energy wave, which provides infrared and heat to the surface of the object being examined. By this, IR-LIT localize and detects failure parts in a discrete semiconductor device. A curve tracer is a piece of electronic test equipment used to analyse the characteristics of semiconductor devices such as reverse leakage current and reverse breakdown voltage. Based on an oscilloscope, the device contains current and voltage sources that can be used to stimulate the device under test (DUT). It works by applying a swept voltage to the terminals of the DUTs, and it measures too the amount of current that the device permits to flow at each voltage. The V-I (voltage versus current) graph or curve is displayed on an oscilloscope screen. However, failure devices can only be examined separately using both machines for troubleshooting. The purpose of this project is to build a hardware comprising of resistors, capacitors and MOSFET to combine the usage of both machines together, in order to get the waveform from the curve tracer and also the image from IR-LIT simultaneously.
ABSTRAK

Kedua-dua mesin curve tracer dan Infrared Lock-in Thermography (IR-LIT) adalah untuk menyelesaikan masalah kegagalan peranti semikonduktor. IR-LIT pada asasnya berdasarkan aplikasi input berkala gelombang tenaga, yang menyediakan inframerah dan haba ke permukaan objek yang diperiksa. Dengan ini, IR-LIT memeriksa lokasi dan mengesan bahagian kegagalan dalam peranti semikonduktor diskret. Curve tracer merupakan sebuah peralatan ujian elektronik yang digunakan untuk menganalisis ciri-ciri peranti semikonduktor seperti kebocoran arus dan pecahan voltan. Berdasarkan osiloskop, peralatan ini mengandungi arus dan sumber voltan yang boleh digunakan untuk merangsang peranti di bawah ujian, iaitu DUT (device under test). Ia berfungsi dengan menyalurkan voltan ke terminal DUTs, dan mengukur jumlah arus yang dibenarkan oleh peranti untuk mengalir pada setiap voltan. VI (voltan versi arus) graf atau lengkung akan dipaparkan pada skrin osiloskop. Walau bagaimanapun, kegagalan peranti hanya boleh diperiksa dengan menggunakan kedua-dua mesin untuk menyelesaikan masalah secara bersasingan. Tujuan projek ini adalah untuk membina sebuah perkakasan yang terdiri daripada perintang, kapasitor dan MOSFET untuk menggabungkan penggunaan kedua-dua mesin, dan mendapatkan gelombang dari curve tracer dan juga imej dari IR-LIT secara serentak.
Tajuk Projek : Combine Infrared Lock-in Thermography and Curve Tracer into an Integrated System

Sesi Pengajian : 1 2 / 1 3

Saya PHUNG LEE MUN (HURUF BESAR) mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:
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TABLE OF CONTENTS

CHAPTER TITLE PAGE

SUPERVISOR’S ENDORSEMENT i
TITLE PAGE ii
DECLARATION iii
DEDICATION iv
ACKNOWLEDGEMENT v
ABSTRACT (ENGLISH) vi
ABSTRACT (BAHASA MELAYU) vii
REPORT VERIFICATION STATUS FORM viii
CONFIDENTIAL COMPANY ix
TABLE OF CONTENTS x
LIST OF TABLES xiii
LIST OF FIGURES xiv

1 INTRODUCTION

1.1 Background 1
1.2 Objective 2
1.3 Problem Statement 2
1.4 Scope Of Work 2
1.5 Project Methodology 3
1.6 Report Structure 3
2 LITERATURE REVIEW

2.1 General Failure Analysis Flow 5
2.2 Devices- Power Mofet 6
   2.2.1 Integrated Circuit (Ic) 7
   2.2.2 Relay 9
2.3 Equipment 9
   2.3.1 Curve Tracer 9
   2.3.2 Infrared Lock-In Thermography 12

3 METHODOLOGY

3.1 Project Planning 16
3.2 Process Planning 17
   3.2.1 Learning Of Curve Tracer 18
   3.2.2 I-V Plot Through General Purpose Interface Bus (Gpib) Procedure 20
   3.2.3 Learning Of Infrared Lock-In Thermography 23

4 RESULT AND DISCUSSIONS

4.1 Mosfet 27
   4.1.1 Dc Power Source 27
4.2 Preliminary Result 28
   4.2.1 Phase 1 – Mosfet As Controller 28
   4.2.2 Phase 2 – Relay As Controller 30
   4.2.3 Phase 3 – Using Infrared Lock-In Thermography As Power Source 33
4.3 Result

4.3.1 Phase 4 – Protection For Components

And Machine During Circuit Testing

5 ANALYSIS AND DISCUSSION OF RESULTS

5.1 Analysis

5.2 Discussion Of Results

6 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

6.2 Recommendation

REFERENCES

APPENDIX
<table>
<thead>
<tr>
<th>NO</th>
<th>CONTENT</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Measurements for MOSFET in curve tracer</td>
<td>10</td>
</tr>
<tr>
<td>3.1</td>
<td>Bipolar Transistor Measurement</td>
<td>19</td>
</tr>
<tr>
<td>3.2</td>
<td>DIODE</td>
<td>19</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>NO</th>
<th>CONTENT</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>General FA flow</td>
<td>5</td>
</tr>
<tr>
<td>2.2</td>
<td>Structure of MOSFET</td>
<td>6</td>
</tr>
<tr>
<td>2.3</td>
<td>Symbol of MOSFET</td>
<td>6</td>
</tr>
<tr>
<td>2.4</td>
<td>(a) Power MOSFET (b) Symbol with notation</td>
<td>7</td>
</tr>
<tr>
<td>2.5</td>
<td>Integrated circuit</td>
<td>7</td>
</tr>
<tr>
<td>2.6</td>
<td>Schematic diagram of an integrated circuit (IC)</td>
<td>8</td>
</tr>
<tr>
<td>2.7</td>
<td>Sinking and sourcing current</td>
<td>8</td>
</tr>
<tr>
<td>2.8</td>
<td>(a) Relay (b) Structure of</td>
<td>9</td>
</tr>
<tr>
<td>2.9</td>
<td>Curve Tracer 370A front panel controls</td>
<td>10</td>
</tr>
<tr>
<td>2.10</td>
<td>ID-VDS curve</td>
<td>11</td>
</tr>
<tr>
<td>2.11</td>
<td>G-D curve</td>
<td>11</td>
</tr>
<tr>
<td>2.12</td>
<td>G-S curve</td>
<td>11</td>
</tr>
<tr>
<td>2.13</td>
<td>Curve Tracer of a good unit and defective unit</td>
<td>12</td>
</tr>
<tr>
<td>2.14</td>
<td>Infrared Lock-in Thermography</td>
<td>13</td>
</tr>
<tr>
<td>2.15</td>
<td>Set up of Infrared Lock-in Thermography</td>
<td>13</td>
</tr>
<tr>
<td>2.16</td>
<td>Detection limit of local dissipated power</td>
<td>14</td>
</tr>
<tr>
<td>2.17</td>
<td>Hot spot on metal surface</td>
<td>14</td>
</tr>
<tr>
<td>2.18</td>
<td>Blurring behavior at different Lock-in frequencies ( f_{\text{Lock-in}} )</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>(a) 1 Hz (b) 10 Hz (c) 30 Hz</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Flow Chart of project planning</td>
<td>16</td>
</tr>
<tr>
<td>3.2</td>
<td>General purpose</td>
<td>20</td>
</tr>
<tr>
<td>3.3</td>
<td>370UTL icon to be selected</td>
<td>20</td>
</tr>
<tr>
<td>3.4</td>
<td>Software file of 370UTL</td>
<td>21</td>
</tr>
</tbody>
</table>
3.5 Curve displayed on curve tracer
3.6 Colour selection on curve
3.7 File extracting in 370A File
3.8 File saving
3.9 (a) Lock-in Thermography (b) Infrared camera
3.10 Main LTI Window
3.11 Lock-in setting window
3.12 Overlay the Amplitude or Phase image
3.13 Saving the overlay image
4.1 DC Power Source in zero-state mode
4.2 The desired curve to be obtained
4.3 Before controlling the DC Power Source
4.4 MOSFET used as controller
4.5 Adjusting voltage to get the desired curve
4.6 Connection of MOSFET to curve trace and DC Power Source
4.7 Curve being obtained after adjusting voltage
4.8 Before controlling the DC Power Source
4.9 Relay used as controller
4.10 Curve being obtained after adjusting voltage
4.11 The power source of lock-in thermography
4.12 The connection of relay and IC to lock-in thermography and curve tracer
4.13 The adjustment of voltage and current to produce and maintain the desired curve
4.14 The curve obtained when power source of IR-LIT is turned on
4.15 Hot spot of failed device
4.16 Schematic diagram of circuit
4.17 Circuit with 1N1418 protection diode
CHAPTER 1

INTRODUCTION

1.1 Background

The process of determining on how a semiconductor device has failed often performed as a series of steps known as Failure Analysis techniques is called the Semiconductor Failure Analysis (FA). Device failure is defined as any non-conformance of the device to its electrical and/or visual or mechanical specifications. Failure analysis is necessary in order to understand the causes of failure and prevent it in the future.

The electrical failure (such as short circuit) can either be functional or parametric. Functional failure refers to the inability of a device to perform its deliberate function, meanwhile, parametric failure refers to the inability of a device to meet the electrical specifications for a measurable characteristic (such as leakage current) that does not directly affect to functionality. Thus, a parametric failure can occur even if the device is still functional or able to perform its intended function.

After failure verification, the analysis of sample requires various FA techniques that needs to be followed step by step, collecting attributes and other observations along the way. In the FA flow, there are two sections which are the destructive test and non-destructive test. It is better to perform the non-destructive FA techniques before the destructive ones. Also, the results of these various FA techniques must be consistent or corroborative. Any inconsistency in results must be resolved before proceeding to the next step. For example, a pin that exhibits a broken wire in a sample during X-ray inspection must not get any acceptable curve while
performing curve tracing, if not, for this inconsistency must be resolved by verifying which of the two results is correct.

1.2 Objective

The objectives of this project are:
1. To determine the curve and location of the failure with the integrated system of curve tracer and IR-LIT.
2. To investigate curve and biasing displayed on the oscilloscope screen on developed circuit.

1.3 Problem Statement

Failure analysis starts with failure verification. The failure verification is the process of validating the failure of a sample or what we called a unit in a semiconductor workplace. Thus, it is crucial to validate the failure of a sample prior to failure analysis in order to conserve valuable FA resources. Failure verification is one of the initial steps to characterize the failure mode. In brief, good characterization of the failure mode is necessary to make the FA efficient and accurate.

A curve tracer is commonly be used for troubleshooting failure devices, as it is able to display curve of characteristic of a device displayed on the oscilloscope screen. However, the exact failure location of the device which comprises of the mould compound, 1st die or 2nd die is not able to be detected. In fact, the IR-LIT is able to localize the exact failure part using internal power source which is the DC Power Source. However, graph and characteristics of failure device could not be observed in the IR-LIT and thus, it would be encouraged to combine both curve tracer and IR-LIT by constructing a hardware circuit. The constructed circuit will be able to combine both machines together in producing the results simultaneously.
1.4 **Scope of work**

First of all, this project will fully work in Infineon Technologies Sdn Bhd, Batu Berendam. The proposed project will focus primarily on curve tracer, as curve tracer will be used as power source instead of the DC Power Source from the IR-LIT. Failed devices are being sent to Department of Failure Analysis. By that, curve tracer will be used to obtain characteristics of failed units and IR-LIT to obtain the failure location. However, this comprises of double workload which deals on both machines separately. From that, this proposed project will be able to integrate the system with chip solution on the proposed circuit. Device under test (DUT) will comprise of bipolar junction transistor (BJT) and power MOSFET.

1.5 **Project methodology**

This project studies the characteristics of curve tracer and infrared lock-in thermography. The steps involved in finding the information are listed below:

(i) Revise on journals and datasheets of both machines.
(ii) Learn up and familiarize with the usage of both machines.
(iii) Designing of circuit.
(iv) Construction of hardware circuit. The circuit built will determine if both machines are able to be integrated by producing both results at the same time.

1.6 **Report structure**

The project report will be divided into 5 chapters which are introduction, literature review, methodology, results, analysis and discussion of results, and lastly conclusion and recommendation.

i. **Chapter 1: Introduction**

   Briefly describe about the project background, problem statement, objectives, scope of the project and the project methodology. In the end of this chapter, there will be summary of this project progress.
ii. Chapter 2: Literature review
   This intensive study of the background of related to the subject of project including the components, machines and requirement. At last but not least, the recent research finding of the curve tracer and infrared lock-in thermography.

iii. Chapter 3: Methodology
   Development of the combine the two readings from the two machines by the a circuit as well as the preliminary data obtained in each phases.

iv. Chapter 4: Results
   All the results and data from the analysis which are collected during the project will be included in this chapter with proper arrangement and presented in order. Several phases would be divided and accordance of results will be implied.

v. Chapter 5: Analysis and Discussion of Results
   In this chapter, it provides discussion based on the results of study, stressing significance and implications of the findings. The discussion includes contribution of the project findings to the field.

vi. Chapter 6: Conclusion and Recommendation
   This chapter concludes the overall of the project and the result and contains summary of the entire work including methods, conclusion and also recommendation.
CHAPTER 2

LITERATURE REVIEW

2.1 General Failure Analysis Flow

After discussing what Failure Analysis is about and some techniques that used to determine the failure on a unit in the previous section, a general Failure Analysis (FA) flow is summarized in Figure 2.1.

Figure 2.1: General FA flow
2.2 Devices - Power MOSFET

Basically, MOSFET is the acronym for metal-oxide-semiconductor field-effect transistor. It is a transistor that uses a control electrode which is called the gate, to vary the conductance of a channel between the source and the drain. Actually MOSFET almost same as the Bipolar Junction Transistor (BJT) where it uses an electric field to control an output. However, the electric field not controls an output. Rather it is controlled by a capacitor. For BJT, it only requires one kind of charge carrier which either holes or electrons once it is activated. A MOSFET is shown in Figure 2.2 below [2].

![Figure 2.2: Structure of MOSFET [2]](image)

From Figure 2.2 above the MOSFET is consists of a substrate (p-type or n-type). There are two islands of the other type which is called the source and the drain. Besides that, a thin layer of silicon dioxide is on top of the islands and substrate. And a metal electrode is over the silicon dioxide between the drain and the source [2].

![Figure 2.3: Symbol of MOSFET [2]](image)
One of the examples of Power MOSFET is

![Power MOSFET and Symbol with notation](image)

Figure 2.4: (a) Power of MOSFET  
(b) Symbol with notation [1]

### 2.2.1 Integrated circuit (IC)

Integrated circuit is a combination of electronic circuits on a small plate surface, or “chip” which is made of semiconductor material, mostly silicon. Figure 2.5 below shows the image of an integrated circuit.

![Integrated circuit](image)

Figure 2.5: Integrated circuit [3,10]

Imaging, deposition and etching are the necessary key process steps which semiconductor ICs are fabricated in layer process.

Devices such as flip-flops, logic gates, counters, shift registers and logic ICs process digital signals. These devices can be split into two groups referring to their pin arrangements which are the 4000 series and the 70 series which consists of different categories namely 74HCT, 74HC and 74LS [2]
The terms of sink or source current by IC outputs depends on the direction of the current at the output of IC.

Current is flowing into the output if the IC is sinking current. A device connected between the IC output and the positive supply (+Vs) will be turned on when the output is low, which is 0V.

Current is flowing out of the output if the IC is sourcing current. A device connected between the IC output and the negative supply (0V) will be turned on when the output is high, which is +Vs [2].

Figure 2.7: Sinking and sourcing current [3,11]
2.2.2 Relay

Relays are known as an electrically operated switch as an electromagnet is used by relays to operate switching mechanisms mechanically. Where several circuits ought to be controlled by one signal and a low power signal which with complete electrical isolation between controlled circuits, relays are necessary to be used [3].

![Relay](image1.png)

![Structure of relay](image2.png)

Figure 2.8: (a) Relay (b) Structure of relay [3]

A magnetic field is generated when an electric current is passed through the coil that armature is activated, and a connection with a fixed contact is being made or broken by the consequent movement of the movable contacts. The movement opens the contacts and breaks its connection if the relay is de-energized and set of contacts was closed, and the other way round when the contacts were open. The armature will be returned by a force, which is about half as strong as the magnetic force when the current to the coil is switched off to its relaxed position. Normally this force is equipped by a spring. However, gravity is also usually been used in industrial motor starters [3].

2.3 Equipment

2.3.1 Curve Tracer

The curve tracer was basically developed as a diode and transistor tester. It allows indication in the view of graphical of the voltage versus current characteristics. This is helpful and essential due to the characteristics of nonlinear